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IoT Based Smart Energy Metering with Blynk Application

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ABSTRACT

The Internet of Things (IoT) is a rapidly growing technology that is changing the way we interact with the world around us. One application of IoT technology is the development of smart energy meter systems. This paper presents the design and implementation of an IoT-based smart energy meter system that can monitor and track the energy consumption of households and businesses. The system is designed to be cost-effective, easy to install, and user-friendly. The system is also scalable, which means that it can be used in both small and large-scale applications.

KEYWORDS: *IOT, Blynk Application, Real time monitoring*

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INTRODUCTION

Energy consumption is a major concern for households and businesses alike. Rising energy costs and the need to reduce greenhouse gas emissions have led to the development of smart energy meter systems. These systems are designed to monitor and track energy consumption in real-time, which canhelp users identify areas where energy is being wasted and make changes to reduce energy consumption.

The smart energy meter system presented in this paper is based on IoT technology. The system consists of several components, including sensors, a microcontroller, a wireless module, and a central server. The system is designed to be cost-effective, easy to install, and user-friendly. The system is also scalable, which means that it can be used in both small and large-scale applications.

Design: The IoT-based smart energy meter system is designed to measure the amount of energy consumed by an electrical device or an entire building. The system uses sensors to detect the amount of electricity flowing through the power lines and transmits this data to a central server via a wireless network.

The central server then processes this data and generates reports that provide detailed information about energy consumption. These reports can be accessed by the end-users through a web- based interface or a mobile application.

Implementation: The IoT-based smart energy meter system consists of several components, including the following:

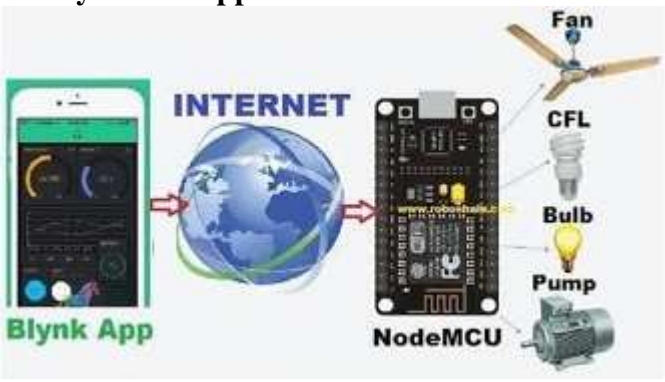
Sensor Module: This module consists of sensors that measure the voltage and current flowing through the power lines. The data from these sensors is sent to the microcontroller for processing.

Microcontroller: This module processes the data received from the sensor module and sends it to the wireless module.

Wireless Module: This module transmits the data received from the microcontroller to the central server over a wireless network.

Central Server: This module receives the data from the wireless module and processes it to generate reports that provide detailed information about energy consumption.

1. Blynk IoT Application:



Blynk is a platform for building IoT (Internet of Things) applications that allows you to easily connect hardware devices, such as smart energy meters, to the internet and control them remotely using a mobile app or web interface. With Blynk, you can create custom interfaces and dashboards that display real-time data from your smart energy meter, such as energy usage, costs, and other metrics.

To create a smart energy meter using Blynk, you will need a compatible hardware device that can measure and transmit energy usage data, such as a smart energy metering device or a microcontroller connected to a current sensor. You will also need to create a Blynk account and set up a project that connects your hardware device to the Blynk cloud.

Once your project is set up, you can use the Blynk app or web interface to view real-time data from your smart energy meter and control it remotely, such as setting thresholds for energy usage, receiving notifications when usage exceeds a certain limit, or turning off appliances remotely to save energy. Blynk also provides analytics and data visualization tools that can help you monitor and optimize your energy usage over time

EXISTING SMART ENERGY METER TECHNOLOGY IN INDIA:

Smart energy meter technology is being widely adopted in India as a means of monitoring and managing energy consumption. The government of India has set a target of installing 250 million smart meters in the country by 2025, and various state electricity distribution companies have already started implementing smart metering solutions.

There are several types of smart energy meters available in India, including:

Prepaid Smart Meters: These meters are designed to work on a prepaid basis and require users to pay in advance for their electricity usage. They offer benefits such as real-time consumption monitoring and alerts for low balance.

Postpaid Smart Meters: These meters work on a postpaid basis, where users are billed based on their monthly usage. They also offer real-time consumption monitoring and allow users to track their electricity usage and costs.

Advanced Metering Infrastructure (AMI) Meters: These meters "Smart metering and electricity demand: Technology, economics, and international experience" by F. Sioshansi (2011): This book provides an overview of smart metering technology and its impact on electricity demand, including the potential benefits and challenges of smart meters in different contexts.

"Smart grid and smart meters: A review" by A. Al-Anbari et al. (2014): This paper provides a comprehensive review of smart grid and smart meter technology, discussing the benefits and limitations of these technologies, as well as potential applications for improving energy efficiency and sustainability.

"A review of the applications of smart meters in the power sector" by M. Kuzlu and K. Ermis (2015): This paper provides a detailed review of the applications of smart meters in the power sector, including energy management, demand response, and real-time monitoring.

"Consumer engagement with smart energy technologies: Lessons from smart meter trials in the UK" by C. Hargreaves et al. (2013): This paper discusses the results of smart meter trials in the UK, focusing on consumer engagement with smart energy technologies and the impact of these technologies on energy consumption behavior.

"Smart meters: An assessment of the global market" by S. Alumni et al. (2017): This paper provides an overview of the global smart meter market, discussing the drivers and barriers to adoption, as well as the potential impact of smart meters on energy efficiency and sustainability.

Overall, the existing literature on smart energy meters provides valuable insights into the potential benefits and challenges of these technologies, as well as their impact on energy consumption, policy, and regulation.

AIM AND OBJECTIVES OF SMART ENERGY METER:

The aim of a smart energy meter is to monitor and measure energy consumption in real-time and provide consumers with information about their energy use to promote more efficient and sustainable energy practices. The main objectives of smart energy meters can vary depending on the context and goals of the particular project or system, but here are some common objectives:

Accurate measurement of energy consumption: Smart energy meters aim to provide accurate and reliable

measurements of energy consumption, which can help consumers understand their energy use and make more informed decisions about how to reduce their energy consumption and costs.

Real-time monitoring and feedback: Smart energy meters can provide real-time monitoring and feedback on energy consumption, allowing consumers to see how much energy they are using and identify opportunities for energy savings.

Improved energy efficiency: Smart energy meters can help consumers and businesses identify areas of energy waste and inefficiency, allowing them to take action to reduce energy use and costs.

Demand response and load management: Smart energy meters can enable demand response and load management programs, which can help to balance energy supply and demand, reduce peak demand, and avoid power outages.

Integration with renewable energy sources: Smart energy meters can enable the integration of renewable energy sources such as solar and wind power, allowing consumers to generate their own energy and sell excess energy back to the grid.

Improved billing and payment systems: Smart energy meters can enable more accurate and transparent billing and payment systems, allowing consumers to pay for the energy they use rather than estimated bills based on historical consumption.

Overall, the aim and objectives of smart energy meters are to promote more efficient, sustainable, and cost-effective energy practices, while improving the reliability and efficiency of the energy system as a whole.

HARDWARE EQUIPMENT:

1. SC – 013 CURRENT TRANSFORMER:

SC-013 is a type of current transformer that can be used for monitoring AC currents in electrical power systems. Here are some of its specifications:

1. Primary Current Rating: SC-013 has a primary current rating of up to 20 A, meaning it is designed to measure AC currents up to 20 amps.
2. Secondary Current Rating: The secondary current rating of SC-013 is 5A, which means it produces a 5A output signal proportional to the measured primary current.
3. Frequency Range: The frequency range of SC-013 is 50-60 Hz, which makes it suitable for use in most standard electrical power systems.
4. Accuracy Class: The accuracy class of SC-013 is 1.0, which means it has an accuracy of ±1% of the rated current.
5. Burden: The burden of SC-013 is 2.5 VA, which means it can handle a maximum load of 2.5 volt-amperes at the secondary side.
6. Insulation Level: SC-013 has an insulation level of 1 kV, which means it can safely operate at a voltage of up to 1000 volts.
7. Physical Dimensions: SC-013 has a compact and lightweight design, with a diameter of 13 mm and a length of 13 mm. It has a split-core construction, which allows it to be easily installed on existing electrical wiring without the need for rewiring or interrupting the circuit.
8. Overall, SC-013 is a reliable and accurate current transformer suitable for a wide range of applications in electrical power systems, including energy management, power monitoring, and protection.

2. ZMPT101B VOLTAGE SENSOR:

ZMPT101B is a voltage sensor that can be used for measuring AC voltages in electrical power systems. Here are some of its specifications:

1. Input Voltage: ZMPT101B is designed to measure AC voltages in the range of 0-250 VAC.
2. Output Voltage: The output voltage of ZMPT101B is 1-5 VDC, which is proportional to the measured AC voltage.

3. Frequency Range: The frequency range of ZMPT101B is 50-60 Hz, which makes it suitable for use in most standard electrical power systems.
4. Accuracy Class: The accuracy class of ZMPT101B is 1.0, which means it has an accuracy of ±1% of the rated voltage.
5. Phase Shift: The phase shift of ZMPT101B is less than 2 degrees, which ensures accurate measurement of AC voltages.
6. Insulation Level: ZMPT101B has an insulation level of 2.5 kVAC, which means it can safely operate at a voltage of up to 2500 volts.
7. Physical Dimensions: ZMPT101B has a compact and lightweight design, with a diameter of 1.5 cm and a height of 2.2 cm. It has a built-in voltage divider circuit and can be easily connected to microcontrollers or other digital devices.
8. Overall, ZMPT101B is a reliable and accurate voltage sensor suitable for a wide range of applications in electrical power systems, including energy management, power monitoring, and protection

3. ESP32 MICROCONTROLLER WITH SPECIFICATION:

ESP32 is a microcontroller chip designed for IoT applications. Here are some of its specifications:

1. Processor: ESP32 is based on a dual-core Ten silica Xtensa LX6 processor, with a clock frequency of up to 240 MHz
2. Memory: ESP32 has 520KB SRAM and 448KB ROM, along with 4MB flash memory for program storage.
3. Connectivity: ESP32 supports Wi-Fi 802.11 b/g/n and Bluetooth v4.2 BLE. It also has a built-in Ethernet MAC with dedicated DMA.
4. GPIO: ESP32 has 34 GPIO pins, which can be used for digital input/output, PWM, and other functions.
5. Analog Input: ESP32 has 18 analog input pins, with a resolution of up to 12 bits.
6. Peripherals: ESP32 has a range of peripheral interfaces, including UART, SPI, I2C, I2S, SD/MMC, and CAN.
7. Power Consumption: ESP32 has low power consumption, with various power modes to conserve energy.
8. Operating Voltage: ESP32 operates on a voltage range of 2.2V to 3.6V.
9. Development Environment: ESP32 can be programmed using the Arduino IDE, MicroPython, or other programming languages.
10. Overall, ESP32 is a powerful and versatile microcontroller chip that can be used for a wide range of IoT applications, including smart energy meters, home automation, and industrial control systems.

SOFTWARE REQUIREMENT:

1. ARDUINO IDE SOFTWARE:

Arduino IDE (Integrated Development Environment) is a software application that is used to write and upload code to Arduino microcontrollers. It is an open-source platform that is available for free and can be downloaded from the Arduino website. Arduino IDE provides a user-friendly interface for writing and editing code, and it includes a range of features such as syntax highlighting, auto-complete, and serial monitor. It supports various programming languages including C, C++, and Arduino's own programming language.

Using the IDE, you can write, compile, and upload code to Arduino boards, as well as access a range of libraries and examples to help you get started with your project. The software also includes a serial monitor that allows you to interact with the microcontroller and view data output in real- time. Overall, the Arduino IDE is a powerful and user-friendly software tool that is essential for anyone working with Arduino microcontrollers. It enables easy and efficient development of code for Arduino-based projects, making it a popular choice for hobbyists and professionals alike.

2. EMON LIBRARY ARDUINO IDE:

The Emon library is a collection of functions for Arduino IDE that enables energy monitoring and management using open- source hardware and software. It was originally developed for the EmonPi

energy monitoring system but can be used with other Arduino-based energy monitoring projects.

The Emon library provides functions for measuring AC voltage and current using current transformers (CTs) and AC-AC power adapters. It also includes functions for calculating real- time power, energy, and other electrical parameters. The library uses digital signal processing techniques to measure and calculate accurate values of voltage, current, and power.

The library includes several examples that demonstrate how to use the Emon functions to create energy monitoring projects. These examples cover a range of applications, including home energy monitoring, solar power monitoring, and energy-efficient appliance control.

The Emon library is open-source and can be downloaded from the Arduino library manager or the Emon library GitHub repository. It is compatible with a range of Arduino boards, including the Arduino Uno, Mega, Nano, and ESP8266.Overall, the Emon library is a powerful and versatile tool that simplifies the process of energy monitoring and management using Arduino-based hardware and software

3. BLYNK LIBRARY ARDUINO IDE:

The Blynk library for Arduino IDE is a collection of functions and tools that enable easy communication between Arduino microcontrollers and the Blynk IoT platform. Blynk provides a range of tools and services for building IoT applications, including a cloud-based platform, mobile apps, and a range of hardware and software components.

The Blynk library for Arduino IDE provides functions for connecting Arduino boards to the Blynk cloud platform, sending and receiving data, and controlling virtual pins. The library includes a range of examples that demonstrate how to use Blynk functions to create IoT applications, including home automation, smart energy management, and industrial control systems. Blynk also provides a mobile app that can be used to control and monitor your Arduino-based IoT applications. The app includes a range of widgets, including buttons, sliders, and gauges, that can be used to interact with your devices and display real-time data.

The Blynk library for Arduino IDE is open-source and can be downloaded from the Arduino library manager or the Blynk library GitHub repository. It is compatible with a range of Arduino boards, including the Arduino Uno, Mega, Nano, and ESP8266.Overall, the Blynk library for Arduino IDE is a powerful and versatile tool that simplifies the process of building IoT applications using Arduino-based hardware and the Blynk cloud platform. It enables easy communication and control between Arduino boards and the cloud, making it a popular choice for hobbyists and professionals alike.

Working

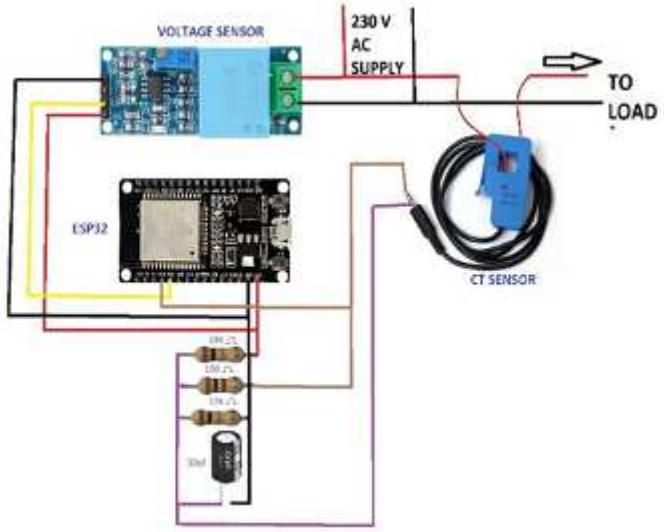


Fig 1 Circuit diagram of Smart Energy Meter

Connection: 5V DC Supply/Adapter is Connected to VCC and GND Pins of ESP32 controller, voltage sensor(ZMPT101B) and (SCT-013-030) Current sensor. The output pin of the voltage sensor is connected to digital pin GPI035 and Current sensor output pin is connected to digital pin GPI034. To the input of voltage sensor 230V, single phase Ac supply is applied. Current sensor is connected to the phase wire of the AC load. Also, two 10k resistors and a single 100 ohm resistor, along with a Capacitor of 10uF required to Complete the circuit.

When 5V DC supply / Adapter is turned ON it will power the ESP32 Controller, Once power ON ESP 32 controller will search for the nearby available Wifi network/ Mobile Hotspot. We need to turn on the Wifi / Hotspot network that is uploaded in the code, the controller will then get Connected to the Wifi network. To monitor the energy consumption of the load Connected, Go to Blynk Application on your mobile or Goto Blynk web Dashboard; Initially as a hardware circuit is turned ON, the meter will show its peak value and the meter will take a few minutes for stabilizing the web server. Now turn On the load Connected.

Let's take an example for this: If the load connected is of 200W This meter will show 80% - 90%approximate value of voltage current and power consumption of the load.

Working Model and Video Link of Project:

Fig 2 Smart Energy Meter compact size model

Video link:
https://drive.google.com/file/d/14Hc4uz1EKw-0_SQkdA3BsJrJODC7ltwS/view?usp=drivesdk

ADVANTAGES:
The smart energy meter system has several advantages, including the following:

1. Improved energy efficiency: By monitoring energy consumption in real-time, the smart energy meter system can help users identify areas where energy is being wasted and make changes to reduce energy consumption.
2. Cost savings: The smart energy meter system can help users reduce their energy bills by providing detailed information about energy consumption and identifying areas where energy is being wasted.
3. Remote monitoring: The smart energy meter system can be monitored remotely, which means that users can access real- time data about their energy consumption from anywhere in the world.
4. Potential Applications: The smart energy meter system has several
5. potential applications, including the following: Residential: The smart energy meter system can be used in residential buildings to monitor energy consumption and reduce energy bills.
6. Commercial: The smart energy meter system can be used in commercial buildings to monitor energy consumption and improve energy efficiency.
7. Industrial: The smart energy meter system can be used in industrial application to monitor the consumption and reduce the waste

CONCLUSION:
The smart energy meter system is an innovative technology that can help users reduce their energy bills, improve energy efficiency, and monitor energy consumption in real-time. With its many advantages and potential applications, the smart

The energy meter system has the potential to revolutionize the way we use and consume energy.

FUTURE SCOPE:
This is the 21st century and there is no space for errors or faults either in any technical system or in general applications. Prepaid energy meters are a beneficial concept for the future. It's facilitating the remission from electricity bills. Electricity vouchers will be available at nearby shops. The word prepaid means "pay before use" . One of the beneficial features of this concept prepaid energy meter is used to prepaid the current supply of electricity to homes, offices etc.

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